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A water vapour barrier and a method of making the same
Vor ref: 22029 DK 1

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A WATER VAPOUR BARRIER AND A METHOD OF MAKING THE SAME

The present invention relates to a water vapour barrier of the type used in building structures such as roof or wall structures. It is well known to use such vapour barriers in the form of plastic films or other sheet materials between a roof or wall structure and a ceiling or wall covering of a room in a building. Usually, the roof or wall structure defines cavities therein which are totally or partly filled with a heat insulating material. Due to for example leakage and/or water vapour condensation caused by variation in temperature moisture may accumulate in the cavities of the roof or wall structure, and such moisture may cause corrosion of structural elements of metal and fungus or rot attack on structural elements of wood.

The international patent application No. WO 96/33321 discloses a water vapour barrier for use in heat insulation of buildings. This known vapour barrier is in the form of a plastic film or a membrane of the type having a water vapour diffusion resistance, which varies in dependency of the relative moisture of surrounding air. This means that when the relative moisture within the roof or wall structure is high, the diffusion resistance of the vapour barrier will be low - typically a diffusion resistance equivalent to 0.2 m air column (according to DIN 52 615) - so that moisture from the cavities of the roof or wall structure may diffuse through the vapour barrier and into the room of the building. However, when the relative moisture within the roof or wall structure is lower than in the room of a building, for example in the winter, the diffusion resistance of the vapour barrier will be higher, typically equivalent to 2 m air column - but a substantial amount of water vapour may diffuse from the room of the building into the roof or wall structure, which is undesirable. Furthermore, this known vapour barrier is water tight, which means that free water which may have leaked into cavities of the roof or wall structure is collected therein and can only very slowly diffuse through the vapour barrier after having been vaporised.

The European patent No. EP 0148870 discloses a vapour barrier formed by a pair of vapour impervious plastic films made from polyethylene, and an intermediate water absorbing layer. The oppositely arranged vapour impervious plastic films have through openings defined therein. However, the openings in the opposite plastic films are offset or displaced in relation to each other. This known vapour barrier structure

allows vapour to diffuse through the barrier and the vapour diffusion resistance is dependent on the character of the intermediate layer of water absorbing material and on the minimum spacings of adjacent openings in the opposite vapour impervious plastic films. This known water vapour barrier also allows free water accumulated within cavities of a roof or wall structure to be drained through the vapour barrier by capillary action. However, when this known laminated water vapour barrier is used, vaporised moisture may diffuse from the roof or wall structure through the vapour barrier into an inner room of the building only when the relative humidity and the temperature difference between the roof or wall structure and the vapour barrier is such that vapour is condensed on the intermediate layer of water absorbing material which is exposed at the openings defined in the outer plastic film. This means that the roof or wall structure may dry out only when the temperature in the roof or wall structure is substantially higher than in the room or inner space of the building.

The present invention provides an improved vapour barrier of the latter type. Thus, the present invention provides a water vapour barrier comprising a first, water impervious membrane having a plurality of first through openings defined therein, a second, water impervious membrane arranged opposite to the first membrane and having a plurality of second through openings defined therein, said first openings being offset in relation to said second openings, and water absorbing material being arranged within one or more spaces being defined between the first and second membranes, each of said spaces interconnecting first and second openings, and the vapour barrier according to the invention is characterised in that at least part of said second membrane is of a material of the type having a water vapour diffusion resistance, which varies in dependency of the relative humidity of air in contact therewith, such that the vapour diffusion resistance is reduced when the relative humidity increases, and vice versa.

The water vapour barrier according to the invention is preferably, but not necessarily, arranged such that the first membrane, which is impervious to water, is facing outwardly, while the second membrane through which water vapour may diffuse is facing the room of the building. By means of the vapour barrier according to the invention moisture may be removed from a roof or wall structure or another similar building structure not only by draining of free water and by removing condensed water vapour by capillary action like the known vapour barrier, but also by diffusion. This

means that the vapour barrier according to the invention is much more efficient in drying cavities or spaces in building structures, which may partly or totally be filled with insulating material, than any of the known vapour barriers.

Like the second water impervious membrane also the first membrane may be of the type having a water vapour diffusion resistance varying in dependency of the relative humidity of the ambient atmosphere. In the presently preferred embodiment of the water vapour barrier according to the invention, however, the first membrane is substantially impervious not only to water, but also to water vapour.

The water absorbing material may, for example, be arranged within a plurality of pockets or spaces which are formed between the first and second membrane, and each of which interconnects one or more of said first openings in the first membrane with one or more second openings formed in the second membrane. Preferably, however, the first and second membranes are connected to opposite sides of said water absorbing material, which is in the form of an intermediate layer.

The characteristics of the water absorbing material forming the intermediate layer, the minimum spacing between adjacent first and second openings in the opposite first and second membranes, and the thickness of the intermediate layer may be chosen so as to obtain a desired draining effect and a desired resistance against moisture transmission from the first to the second openings by capillary action. It has been found that the thickness of the intermediate layer of water absorbing material should preferably be 0.2-1.5 mm.

The intermediate layer may be formed by any suitably water absorbing material, such as a porous, moisture resistant material. Preferably, however, the intermediate layer is a fibrous material and may comprise modified natural or man-made fibres, such as modified cellulose fibres or plastic fibres which may, for example, be impregnated with a fungicide. In the preferred embodiment the intermediate layer is formed by a mixture of plastic fibres, such as polypropylene and acrylic fibres. The fibres may have a core, which is hydrophobic, and an outer surface which is hydrophilic.

The first membrane is, of course, not totally impervious to water vapour, but should preferably show a vapour diffusion resistance being equivalent to at least 10 m air column at any moisture conditions. Usually, the water vapour diffusion resistance of the first membrane, which is said to be substantially impervious to water vapour, should be equivalent to 10-40 m air column at any relative humidity of air in contact therewith. The first membrane could be formed in situ, for example by spraying the membrane in a liquid condition on one side surface of the intermediate layer of water absorbing material. Preferably, however, the first membrane is a film or foil made from a plastic or a metallic material, such as polyethylene, aluminium or an alloy thereof. In the presently preferred embodiment the first membrane comprises a polyethylene film having a weight of 20-100 g/m^2, preferably 30-80 g/m^2.

The water vapour diffusion resistance of the second membrane is preferably equivalent to at least 2 m air column at a relative humidity of 20-50% and less than 1 m air column at a relative humidity of 60-100% of air in contact with the membrane. This means that when the water absorbing material is moist or the air within the water absorbing material has a high relative humidity the resistance against moisture diffusion from the water absorbing material through the second membrane and into the inner space or room of the building is low. Consequently, moisture may be removed from the cavities or spaces in the roof or wall structure relatively quickly. However, in winter time when the relative humidity of the outside atmosphere may be lower than the relative humidity of the air inside the building, the resistance against diffusion of water vapour from the inner space or room of the building into the roof or wall structure is relatively high.

In a preferred embodiment, the water vapour diffusion resistance of the second membrane is even higher and may be equivalent to at least 5 m air column at a relative humidity of 20-50%. Furthermore, the water vapour diffusion resistance of the second membrane may be equivalent to less than 0.5 m air column, and preferably about 0.1 m or less at a relative humidity of 60-100% of air in contact with the membrane, whereby the moisture transmission capacity of the vapour barrier is increased substantially.

At least part of the second membrane may be made from any of the known materials having a water vapour diffusion resistance which is dependent on the relative humidity of air in contact therewith, for example the materials disclosed in the above mentioned international application WO96/33321. As example the second membrane may comprise any of the following materials or any combinations thereof, namely polyamide, ethylene-vinyl alcohol-copolymer, polyvinyl alcohol, polyurethane, protein derivatives, methyl-cellulose, linseed oil alkyd, and bone glue. Some of these materials are suitably made in the form of a film which is adhered to or laminated with the intermediate layer of water absorbing material. Other of the materials mentioned may be formed into the second membrane by being applied to, for example sprayed onto a side surface of the intermediate layer of water absorbing material in a liquid condition.

A preferred embodiment of the vapour barrier according to the invention further comprises a moisture distributing outer layer of water absorbing material which is connected to the outer surface of the first membrane. Such moisture distributing layer may efficiently absorb and distribute free leakage water or condensed vapour and transfer such water to the water absorbing material, which is positioned between the first and second membranes and exposed at the openings formed in the first membrane. This outer layer of water absorbing material may be of any suitable type, for example of the same type as that used in the water absorbing intermediate layer. Thus, the outer layer of water absorbing material may be a fibrous, felt-like material, which may, for example, contain a mixture of plastic fibres. The thickness of this outer layer is preferably rather small, for example less than 0.5 mm and preferably about 0.1 mm.

Any of the first and second membranes may be continuous films or foils in which a plurality of openings, which may have any suitable contour, such as circular, elliptical, triangular or rectangular, are formed. Furthermore, the total area of the openings in the first and second membranes may be different, thus, as an example the total area of the openings in the second membrane may exceed the area of the openings in the first membrane.

In the preferred embodiment the first and second membranes are formed by mutual parallel, transversely spaced first and second bands or strips, respectively, and the

first and second openings in the first and second membranes, respectively, are then defined between adjacent first and second bands, respectively. As mentioned above, the first and second openings do not mutually overlap, but should be offset. Preferably, the minimum spacing between first and second openings, which are defined in the first and second membranes, respectively, is about 20 mm in order to obtain a sufficient resistance against the capillary transmission of water from a first opening in the first membrane to and adjacent second opening in the second membrane.

When the first and second membranes are formed by first and second bands, respectively, each of the second bands may have a width exceeding the width of a corresponding strip-like space between adjacent first bands, so that such second band overlaps not only such space in the first membrane, but also adjacent rim portions of said adjacent first bands. In such case the maximum transverse overlap of the rim portions of the adjacent first band may be 100 mm. However, preferably such maximum transverse overlap is 70 mm.

In the preferred embodiment the vapour barrier according to the invention is in the form of a web-like material with the parallel, band-shaped or strip-like openings extending in the longitudinal direction of the web-like material.

The invention also provides a method of making a water vapour barrier of the type described above, said method comprising forming an elongated layer of water absorbing fibrous material, applying to a first side surface of the layer of water absorbing material a plurality of transversely spaced, parallel first bands of a first, water impervious membrane material, and applying to an opposite, second side surface of the layer of water absorbing fibrous material a plurality of transversely spaced, parallel second bands, at least some of which are of a second, water impervious membrane material, which is of the type having a water vapour diffusion resistance, which varies in dependency of the relative moisture of air in contact therewith, each of said second bands having a width exceeding the width of a corresponding space between adjacent first bands and being applied so as to overlap said space and adjacent rim portions of said adjacent first bands.

At least some of the first and second bands may be films or foils which are adhered to the side surfaces of the layer of water absorbing fibrous material. The first bands, may, for example, be polyethylene films or foils which are connected to thermoplastic fibrous of the layer of water absorbing material by heating or fusing. Preferably, at least some of the second bands are fastened to the layer of water absorbing material by means of a glue, being applied at spaced locations. This may be done by interposing net-like bands of a suitable polymer glue between said second bands and the layer of water absorbing material and by subsequently activating the glue, for example by heating.

The invention will now be further described with reference to the drawings, wherein

Fig. 1 is a fractional sectional view of a roof structure including a water vapour barrier according to the invention,

Fig. 2 is a diagrammatic sectional view of an embodiment of the water vapour barrier according to the invention shown in an enlarged scale, and

Fig. 3 is a perspective view of a rolled up web-like water vapour barrier according to the invention.

The roof structure shown in Fig. 1 comprises a wooden frame including rafters 10 (only one shown in Fig. 1) and a layer of boards 11, which are fastened to the upper sides of the rafters 10. The spaces defined between the rafters 10 and by the layer of boards 11 are filled with a heat insulating material, such as mineral wool 12. The layer of boards 11 is covered by an outer layer of roofing felt 13 and by a water tight film or foil 14 arranged between the roofing felt and the boards 11. The inner side of the heat insulating material or mineral wool 12 is covered by a water vapour barrier 15 according to the invention, and the inner side of the vapour barrier is covered by lining plates, such as plasterboards 16 which are fastened to laths 17. The purpose of the water vapour barrier 15 shown in Fig. 1 is to allow possible moisture collected within the spaces defined between the rafters 10 to migrate through the vapour barrier 15 and into the room below the plasterboards 16. The moisture may, for example, be free

water having passed through possible leaks in the roofing felt 13 and/or the film 14, or it may be condensed water vapour or air with a high relative humidity.

Fig. 2 diagrammatically illustrates the embodiment 15 of the water vapour barrier according to the invention more in detail. The water vapour barrier 15 shown in Fig. 2 comprises an intermediate thin layer 18 of a water absorbent material, such as a fibrous material which may be a mixture of polypropylene fibres and acrylic fibres. The thickness of the layer 18 may, for example, be 0.5-1 mm. A first membrane 19 of a polyethylene film is fastened to the upper surface of the intermediate fibrous layer 18. The first membrane 19 is formed by a number of mutually parallel bands 20 of a polyethylene film. The bands or strips 20 are mutually transversely spaced so as to form band-like or strip-like openings 21 therebetween. A second membrane 22 is applied to the lower surface of the intermediate layer 18, for example by means of a polymer glue. The second membrane 22 is also formed by a number of parallel bands or strips 23 of plastic film. Each of these bands or strips is positioned opposite to one of the openings 21, so as to overlap not only this opening, but also adjacent rim portions of the bands 20. At least some of the bands or strips 23 are made from a plastic material of the type having a water vapour diffusion resistance which is dependent on the relative humidity of the air being in contact therewith. Thus, at least some of the strips 23 may be made from polyamide. Also the strips or bands 23 are mutually transversely spaced so as to define band-like or strip-like openings 24 therebetween, and as shown in Figs. 2 and 3 these openings are transversely offset in relation to the openings 21 formed in the first membrane 19. The opposite surface of the first membrane 19 is covered by a fibrous, water absorbing layer 25, which is preferably rather thin, for example 0.1 mm.

As explained above, moisture may pass from the spaces of the roof structure through the water vapour barrier and into an inner room of the building in various ways. Free water which comes into contact with the outer water absorbing layer 25 will be distributed along the upper surface of the first membrane 19 and passed to the openings 21 in the first membrane where the water may come into contact with and be absorbed by the intermediate layer 18. Now, as indicated by an arrow 26 the water may be passed to the opening 24 in the second membrane 22 by draining or capillary effect. Furthermore, as long as the relative humidity of air within the roof

structure and consequently at the openings 21 in the first membrane 19 is higher than in the room defined by the plasterboards 16, water vapour also diffuses through the second membrane 22 as indicated by an arrow 27 in Fig. 2. However, in case the relative humidity of air within the roof structure drops below the relative humidity of air in the inner space of the building, the vapour diffusion resistance of the second membrane will increase so that only negligible amounts of humidity may pass into the spaces defined by the roof structure.

It should be understood that the water vapour barrier according to the invention may also be used in connection with other parts of buildings, such as wall structures. Because the water vapour barrier according to the invention allows moisture to pass from the outer to the inner side not only by capillary action, but also by diffusion, the vapour barrier according to the invention is much more efficient than similar known water vapour barriers.

CLAIMS

1. A water vapour barrier (15) comprising

a first, water impervious membrane (19) having a plurality of first through openings (21) defined therein,

a second, water impervious membrane (22) arranged opposite to the first membrane (19) and having a plurality of second through openings (24) defined therein, said first openings (21) being offset in relation to said second openings (24), and

water absorbing material (18) being arranged within one or more spaces being defined between the first and second membranes (19,22), each of said spaces interconnecting first and second openings (21,24),

characterised in that at least part of said second membrane (22) is of a material of the type having a water vapour diffusion resistance, which varies in dependency of the relative humidity of air in contact therewith, such that the vapour diffusion resistance is reduced when the relative humidity increases, and vice versa.

2. A vapour barrier according to claim 1, wherein the first membrane (19) is substantially impervious to water vapour.

3. A vapour barrier according to claim 1 or 2, wherein the first and second membranes (19,22) are connected to opposite sides of said water absorbing material, which is in the form of an intermediate layer (18).

4. A vapour barrier according to claim 3, wherein the thickness of the intermediate layer (18) of water absorbing material is 0.2-1.5 mm.

5. A vapour barrier according to claim 3 or 4, wherein the intermediate layer (18) of water absorbing material is a fibrous plastic material comprising fibres having a hydrophobic fibre core.

6. A vapour barrier according to any of the claims 2-5, wherein the water vapour diffusion resistance of the first membrane (19) is equivalent to 10-40 m air column at any relative humidity of air in contact therewith.

7. A vapour barrier according to any of the claims 1-6, wherein the first membrane is a film or foil (19).

8. A vapour barrier according to any of claims 1-7, wherein the first membrane (19) is made from plastic or metallic material.

9. A vapour barrier according to claim 8, wherein the first membrane (19) is made from polyethylene.

10. A vapour barrier according to claim 9, wherein the first membrane (19) comprises a polyethylene film having a weight of 20-100 g/m^2, preferably 30-80 g/m^2.

11. A vapour barrier according to any of the claims 1-10, wherein the water vapour diffusion resistance of the second membrane (22) is equivalent to at least 2 m air column at a relative humidity of 20-50% and less than 1 m air column at a relative humidity of 60-100% of air in contact with the membrane.

12. A vapour barrier according to claim 11, wherein the water vapour diffusion resistance of the second membrane (22) is equivalent to at least 5 m air column at a relative humidity of 20-50%.

13. A vapour barrier according to claim 11 or 12, wherein the water vapour diffusion resistance of the second membrane (22) is equivalent to less than 0.5 m air column, preferably about 0.1 m or less, at a relative humidity of 60-100% of air in contact with the membrane.

14. A vapour barrier according to any of the claims 1-13, wherein said at least part of the second membrane (22) is made from at least one material selected from the group consisting of polyamide, ethylene-vinyl alcohol-copolymer, polyvinyl alcohol, polyurethane, protein derivatives, methyl cellulose, linseed oil alkyd, and bone glue.

15. A vapour barrier according to any of the claims 1-14, further comprising a moisture distributing outer layer (25) of water absorbing material, which is connected to the outer surface of said first membrane (19).

16. A vapour barrier according to claim 15, wherein the outer layer (25) of water absorbing material is a fibrous, felt-like material.

17. A vapour barrier according to claim 16, wherein the thickness of the outer layer (25) of water absorbing material is less than 0.5 mm, preferably about 0.1 mm.

18. A vapour barrier according to any of the claims 1-17, wherein each of the first and second membranes (19,22) are formed by mutually parallel, transversely spaced first and second bands (20,23), respectively, the first and second through openings (21,24) being defined between adjacent first and second bands (20,23), respectively.

19. A vapour barrier according to any of the claims 1-18, wherein the minimum spacing between first and second openings (21,24) defined in the first and second membranes (19,22), respectively, is about 20 mm.

20. A vapour barrier according to claim 18, wherein each of said second bands (23) has a width exceeding the width of a corresponding space (21) between adjacent first bands (20) and overlaps said space and adjacent rim portions of said adjacent first bands.

21. A vapour barrier according to claim 20, wherein the maximum transverse overlap of the rim portions of the adjacent first bands (20) is 100 mm.

22. A vapour barrier according to claim 21, wherein the maximum transverse overlap is 70 mm.

23. A vapour barrier according to any of the claims 18-22 and being in the form of a web-like material, the parallel, band-shaped openings (21,24) extending in the longitudinal direction of the web-like material.

24. A method of making a water vapour barrier, said method comprising

forming an elongated layer of water absorbing, fibrous material (18),

applying to a first side surface of the layer of water absorbing, fibrous material (18) a plurality of transversely spaced, parallel first bands (20) of a first, water impervious membrane material, and

applying to an opposite, second side surface of the layer of water absorbing, fibrous material (18) a plurality of transversely spaced, parallel second bands (23), at least some of which are of a second membrane material, which is of the type having a water vapour diffusion resistance, which varies in dependency of the relative moisture of air in contact therewith,

each of said second bands (23) having a width exceeding the width of a corresponding space (21) between adjacent first bands (20) and being applied so as to overlap said space and adjacent rim portions of said adjacent first bands.

25. A method according to claim 24, wherein said first membrane material is substantially impervious to water vapour.

26. A method according to claim 24 or 26, wherein at least some of said first and second bands (20,23) are films or foils which are adhered to the side surfaces of the layer of water absorbing fibrous material (18).

27. A method according to claim 25 or 26, wherein the first bands (20) are polyethylene films or foils which are connected to thermoplastic fibres of the layer (18) of water absorbing material by heating and fusing.

28. A method according to any of the claims 24-27, wherein at least some of the second bands (23) are fastened to the layer of water absorbing material (18) by means of a glue.

29. A method according to claim 28, wherein net-like bands of a suitable polymer glue are interposed between said second bands (23) and the layer of water absorbing material (18).

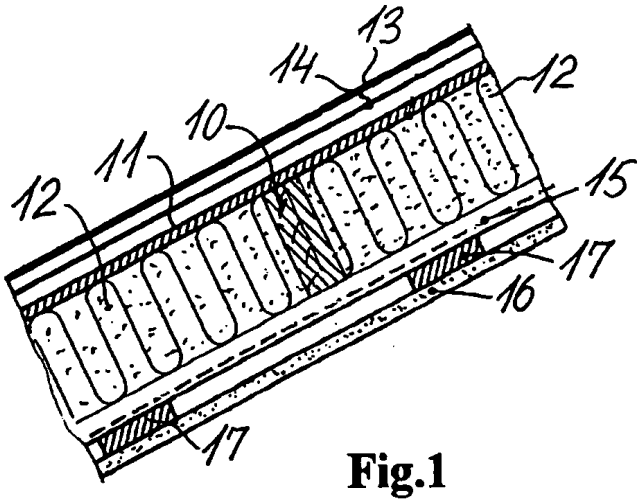

Fig.1

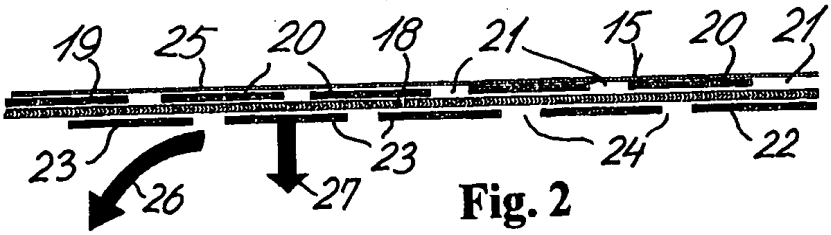

Fig. 2

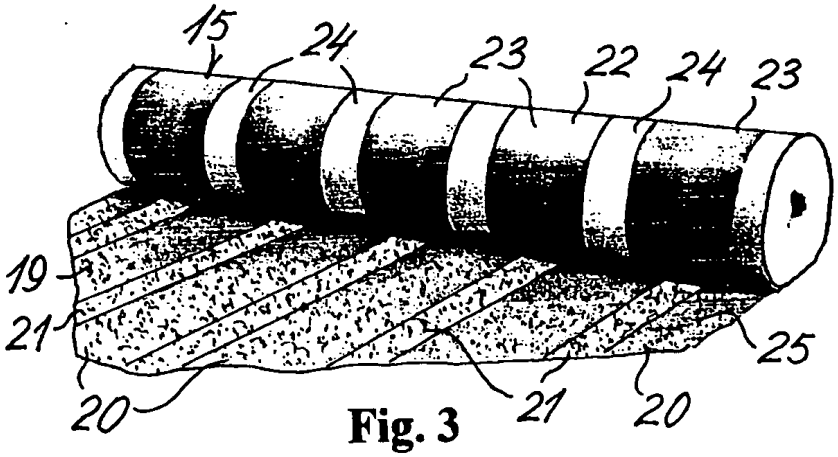

Fig. 3